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Owner/Applicant: Toyota Jidosha Kabushiki Kaisha

In response to the International Search Report and the Written Opinion of the International Searching Authority dated August 10, 2005 and as enclosure to the Demand for the International Preliminary Examination according to **Art. 33 PCT**, the following amended application documents according to **Art. 34 PCT** are herewith submitted:

- an amended set of **claims 1 to 9** (fair copy as well as work sheet) replacing claims 1 to 13 as presently on file, and

- amended description pages **3, 3a, 3b, 3c and 4 to 7** (fair copy), replacing page **3 to 7** as presently on file.

All further application documents are to be maintained unamended.

Moreover submission of new documents has not to be understood so as to waive on any subject matter as originally filed.

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The additionally submitted work sheets of amended description pages **3, 3a, 3b, 3c, 4 to 6, 6a and 7** correspond to description pages **3, 3a, 3b, 3c and 4 to 7** as submitted in fair copy and are meant for an easier determination of the respective amendments carried out.

1. Amendments and original disclosure

The new features of new claim 1 find their basic disclosure in originally filed claims 5 and 9 as well as in Figures 5 and 6.

Further, claim 4 as well as claims 7 and 8 have been deleted.

The remaining claims have been accordingly adapted to the afore-mentioned amendments.

The features of new independent claim 9 find their basic disclosure on page 11, line 9, and page 11, last line to page 12, line 9.

Therefore, all features of the amended set of claims now on file have a sufficient basis in the original disclosure.

2. Novelty

Contrary to the assessment in the International Search Report and the Written Opinion, document **US 2002/0122970 A1 (D1)** is considered as closest prior art document since document **US 2002/0182471 A1 (D4)** which has been considered as closest prior art document in the International Search Report and the Written Opinion merely discloses a fuel cell stack having flow channels formed in the respective plates by bonding theses plates to each other. A sealing structure comprising the features of claim 1 is, however, not disclosed in **D4**.

Therefore, **D1** discloses a method for fabricating a seal-integrated separator for a fuel cell, wherein a seal-integrated separator having first to fourth seals which are integrated on both sides of the separator body is fabricated.

However, the seal-integrated separator known from **D1** differs from the subject-matter of new claim 1 in particular in that

said back-up is formed in said separator and includes a rib having a convex and concave structure.

Hence, the subject-matter of new claim 1 is novel against closest prior art **D1**.

Further, document **D1** does also not disclose that an interrupted backup is formed at a connecting coolant passage, wherein said interrupted back-up disposed at said connecting coolant passage is made from a seal material.

Hence, the subject-matter of new claim 9 is also novel against closest prior art **D1**.

3. Inventive step

3.1. The system known from closest prior art **D1** bears the disadvantage that a gas seal and a coolant seal at the opposite sides of the separator cannot operate as a back-up to each other.

Therefore, the sealing characteristic and stability of the seal on a rear side of the interrupted seal portion are decreased.

3.2. Starting from closest prior art disclosed in document **D1**, it was an object of the present invention to provide a seal structure of a fuel cell where good sealing characteristic and good stability of a seal are assured even at gas and coolant connecting passages between the gas and coolant manifolds and the gas and coolant passages of a central portion of the fuel cell.

It was a further object of the present invention to provide a seal structure of a fuel cell where good sealing characteristic and good stability of a seal are assured even when the a width of the gas manifold and a width of the coolant manifold are different from each other.

This object is solved with the subject-matters of new claim 1 as well as of new claim 9.

Here, it is possible for the first time to assure a sufficient sealing characteristic and stability of a seal by provision of an interrupted back-up that is formed in the separator itself.

Further, due to the provision of interrupted back-up in the separator, no further material for building a respective seal is necessary since it is possible to build the interrupted back-up in a respective structure of the separator base material itself.

3.3. In contrast thereto, **D1** discloses a seal-integrated separator having first to fourth seals which are integrated on both sides of the separator and which are built separately from the separator.

The skilled person could not gather any hint from document **D1** that the respective seals operate as back-up for each other.

Further, the skilled person would recognize from Fig. 2 of document **D1**, referred to as relevant in the Written Opinion, and the description belonging thereto, that the respective interrupted seal portions are built in the gasket.

Therefore, document **D1** does not provide any hint for the skilled person to build an interrupted back-up in the separator itself.

Further, no hint can be gathered from document **D1** that due to provision of an interrupted back-up in the separator that includes a rib having a convex and concave structure, the stability of the seal could be significantly increased without need for additional sealing structures and without interference of fluid flow through the back-up.

Further, the skilled person could not gather any hint from **D1** that the interrupted back-up can be formed easily by simply changing the design of the respective part of the separator, therefore not requiring further sealing materials or forming steps.

3.4. The additionally cited prior art documents are also not suitable to render the subject-matter of the present invention obvious:

3.4.1. Document **US 2003/0091885 A1 (D2)** discloses an electrolyte membrane-gasket assembly for a fuel cell, including a polymer electrolyte membrane and a gasket, made of a seal material, covering the peripheral portion of the electrolyte membrane, in which the electrolyte membrane has a sequence of a plurality of through-holes in the peripheral portion, and a portion of the gasket covering one surface of the electrolyte membrane and a portion covering the other surface are connected to each other through the through-holes of the electrolyte membrane

However, document **D2** does not provide a hint for the skilled person to provide an interrupted back-up including a rib having a convex and concave structure.

Further, document **D2** does also not provide a hint for the skilled person to form the back-up in the separator itself.

3.4.2. Document **US 2003/0186106 A1 (D3)** discloses a fuel cell stack comprising a plurality of fuel cells, each having an anode flow field plate, a cathode flow field plate and a membrane electrode assembly disposed between the flow field plates. The anode and cathode flow field plates have primary channels and ribs separating the primary channels. At least a portion of the anode and cathode primary channels are disposed directly opposite one another with a membrane exchange assembly therebetween and with at least some of the ribs on the anode and cathode flow field plates located directly opposite one another to sandwich the membrane exchange assembly therebetween.

However, document **D3** as such does not provide a hint for the skilled person to provide an interrupted back-up including a rib having a convex and concave structure, wherein the interrupted back-up is formed in the separator itself.

3.4.3. Document **US 2002/0182471 A1 (D4)** discloses a sealing method and apparatus for a fuel cell stack that includes a stack of flow plates, a first gasket that is compatible with a coolant and a second gasket that

is incompatible with the coolant. The first gasket forms a seal around a coolant manifold passageway between an adjacent pair of plates. At least one region of a particular plate may be associated with a reactant flow, and this plate may include internal passageways that extend between manifold passageways to communicate a coolant. A seal that is substantially permanent isolates the internal passageways from the regions of the fuel cell plate that may be associated with reactant flows.

However, contrary to the statement of the Written Opinion that the subject-matter of the present invention is already disclosed in figures 3, 4 and 8, the skilled person would recognize that document **D4** and especially the respective figures merely describe flowing channels formed in the respective plates.

Especially, based on the description of the respective figures, the skilled person would recognize that document **D4** teaches that an anode cooler plate is bonded to a cathode cooler plate, as shown in Fig. 4, to form a cooler plate that is depicted in figures 5 to 7. By bonding the respective plates flow channels are built.

Therefore, the skilled person could gather no hint from the entire document **D4** that the sealing quality can be assured due to provision of an interrupted back-up including a rib having a convex and concave structure, wherein the interrupted back-up is formed in the separator itself.

3.4.4. Document **US 2003/0072988 A1 (D5)** discloses seals for fuel cells and fuel cell stacks, wherein in a fuel cell stack assembly having a plurality of plates with grooves for accommodating gaskets. Seals are provided between individual fuel cell plates in the fuel cell stack assembly in order to prevent leakage of gases and liquids required for operation of the fuel cell stack assembly.

In contrast to the statement given in the Written Opinion as regards the relevance of Fig. 6a, the skilled person could not gather any hint therefrom to arrive at the subject-matter of the present invention.

Moreover, document **D5** does not at all provide a hint for the skilled person to provide an interrupted back-up including a rib having a convex and concave structure, wherein the interrupted back-up is formed in the separator itself.

3.4.5. Document **US 2002/0031698 A1 (D6)** discloses a fuel cell having sealant for sealing a solid polymer electrolyte membrane, wherein a seal contacts the projecting portion which extends from the solid polymer electrolyte membrane and which projects from the peripheries of the anode side diffusion electrode and the cathode side diffusion electrode while the membrane electrode assembly is disposed between the separators.

However, also document **D6** does not provide a hint for the skilled person to provide an interrupted back-up including a rib having a convex and concave structure, wherein the interrupted back-up is formed in the separator itself.

3.4.6. Document **EP 1 302 996 A2 (D7)** discloses a polymer electrolyte fuel cell comprising a unit cell, comprising a membrane electrode assembly (MEA) comprising a polymer electrolyte membrane, a gasket covering the periphery of the electrolyte membrane, an anode and a cathode attached to the electrolyte membrane; and conductive separator plates sandwiching the MEA therebetween.

However, document **D7** does not suggest to use an interrupted back-up.

Further, document **D7** does also not provide a hint for the skilled person to provide an interrupted back-up including a rib having a convex and concave structure, wherein the interrupted back-up is formed in the separator itself.

3.5. **Summarizing**, the cited prior art documents **D1 to D7** neither describe nor show all characterizing features of the amended set of claims of the present invention and therefore differ in these features from the subject-matter claimed.

Especially, no one of these documents discloses that an interrupted back-up is formed in a separator and includes a rib having a convex and concave structure.

Moreover, none of the cited references discloses the features of new independent claim 9.

However, from the viewpoint of safety, leakage of gas is to be suppressed more severely than leakage of coolant.

Therefore, by providing said interrupted backup at the connecting coolant passage as claimed in new independent claim 9, leakage can be effectively prevented.

Therefore, since not all characterising features of the present invention are known with the cited state of the art, the teachings of **D2 to D7** are also not applicable to make the claimed combination of features obvious in synopsis with the closest state of the art **D1**.

In absence of examples from the prior art which could provide a solution for the object of the present invention, the skilled person could not gather any hint from these documents to arrive at the subject-matter of new claims 1 or 9.

The subject-matter of the present invention is therefore based on an inventive step.

4. Formalities

The description has been adapted to the afore-mentioned amendments within the set of claims. Further, cited prior art documents **D1 to D7** are now briefly discussed on new pages **3a, 3b** of the introductory part of the description.

In view of the afore discussed facts and in view of having fulfilled all formal requirements according to PCT, it is now respectfully requested to establish a positive International Preliminary Examination Report (IPER).

In case there should still remain basic objections to patentability of the subject-matter claimed, a

Hearing

according to **Art. 34(2)(a) PCT** and **Rule 66.6 PCT** is herewith respectfully requested. In order to agree upon a mutually convenient date, the Examiner is asked to contact the undersigning attorney.

If only minor amendments are considered to be necessary, it is requested to also get in touch by phone with the attorney who undersigned this petition, so that amended papers immediately can be filed in order to expedite the procedure.

Patent Attorney
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Enclosures:
amended set of claims 1 to 8 (as work sheet and fair copy);
new description pages 3, 3a, 3b, 3c and 4 to 7 (fair copy);
new description pages 3, 3a, 3b, 3c, 4 to 6, 6a and 7 (work sheet);

work sheet

(amended) Claims

1. A seal structure of a fuel cell, said fuel cell including an MEA, a separator, a gas passage formed in said separator, a gas manifold formed in said separator, a connecting gas passage formed in said separator and between said gas passage and said gas manifold, a coolant passage formed in said separator, a coolant manifold formed in said separator, a connecting coolant passage formed in said separator and between said coolant passage and said coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line, said seal structure of a fuel cell comprising an interrupted back-up disposed at at least one of said connecting gas passage and said connecting coolant passage, said back-up located on one side of said separator and a portion of seal line located on the other side of said separator being disposed such that said back-up and said portion of said seal line are overlapped with each other in a fuel cell stacking direction, characterized in that said back-up is formed in said separator and includes a rib having a convex and concave structure.

2. A seal structure of a fuel cell according to claim 1, wherein said back-up is disposed at said connecting gas passage between said gas passage and said gas manifold.

3. A seal structure of a fuel cell according to claim 1, wherein said back-up is disposed at said connecting coolant passage between said coolant passage and said coolant manifold.

~~4.A seal structure of a fuel cell according to any one of claims 1 - 3, wherein said back-up is formed in said seal.~~

~~5.A seal structure of a fuel cell according to any one of claims 1 - 3, wherein said back-up is formed in said separator.~~

~~6.~~4. A seal structure of a fuel cell according to claim 1, wherein though said gas manifold and said coolant manifold differs in width to each other, said interrupted back-up and a portion of said seal line positioned in an extension of said interrupted back-up are disposed on a same straight line.

~~7.A seal structure of a fuel cell according to claim 1, wherein said seal is made from adhesive and said back-up is made in said seal and includes a plurality of non-coated portions of adhesive which are spaced from each other in a back-up extending direction.~~

~~8.A seal structure of a fuel cell according to claim 1, wherein said seal is made from a rubber gasket and said back-up is formed in said seal and includes a~~

~~plurality of gasket material removed portions which are spaced from each other in a back-up extending direction.~~

~~9.A seal structure of a fuel cell according to claim 1, wherein said back-up is formed in either one of said seal and said separator and includes a rib having a convex and concave structure.~~

~~10.~~5. A seal structure of a fuel cell according to claim 1, wherein said back-up is formed in ~~either one of said seal and~~ said separator and includes a plurality of protrusions spaced from each other.

~~11.~~6. A seal structure of a fuel cell according to claim 1, wherein said back-up is formed in ~~either one of said seal and~~ said separator and includes a rib having a plurality of tunnels formed in said rib and spaced from each other.

~~12.~~7. A seal structure of a fuel cell according to claim ~~5~~1, wherein an entire portion of said back-up located between adjacent separators is formed in either one separator of the adjacent separators.

~~13.~~8. A seal structure of a fuel cell according to claim ~~5~~1, wherein a portion of said back-up located between adjacent separators is formed in one separator of the adjacent separators, and a remaining portion of said back-up located

between adjacent separators is formed in the other separator of the adjacent separators.

9. A seal structure of a fuel cell, said fuel cell including an MEA, a separator, a gas passage formed in said separator, a gas manifold formed in said separator, a connecting gas passage formed in said separator and between said gas passage and said gas manifold, a coolant passage formed in said separator, a coolant manifold formed in said separator, a connecting coolant passage formed in said separator and between said coolant passage and said coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line, said seal structure of a fuel cell comprising an interrupted back-up disposed at at least one of said connecting gas passage and said connecting coolant passage, said back-up located on one side of said separator and a portion of seal line located on the other side of said separator being disposed such that said back-up and said portion of said seal line are overlapped with each other in a fuel cell stacking direction, characterized in that said interrupted back-up disposed at said connecting coolant passage is made from a seal material.

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(amended) Claims

1. A seal structure of a fuel cell, said fuel cell including an MEA, a separator, a gas passage formed in said separator, a gas manifold formed in said separator, a connecting gas passage formed in said separator and between said gas passage and said gas manifold, a coolant passage formed in said separator, a coolant manifold formed in said separator, a connecting coolant passage formed in said separator and between said coolant passage and said coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line, said seal structure of a fuel cell comprising an interrupted back-up disposed at at least one of said connecting gas passage and said connecting coolant passage, said back-up located on one side of said separator and a portion of seal line located on the other side of said separator being disposed such that said back-up and said portion of said seal line are overlapped with each other in a fuel cell stacking direction, characterized in that said back-up is formed in said separator and includes a rib having a convex and concave structure.

2. A seal structure of a fuel cell according to claim 1, wherein said back-up is disposed at said connecting gas passage between said gas passage and said gas manifold.

3. A seal structure of a fuel cell according to claim 1, wherein said back-up is disposed at said connecting coolant passage between said coolant passage and said coolant manifold.

4. A seal structure of a fuel cell according to claim 1, wherein though said gas manifold and said coolant manifold differs in width to each other, said interrupted back-up and a portion of said seal line positioned in an extension of said interrupted back-up are disposed on a same straight line.

5. A seal structure of a fuel cell according to claim 1, wherein said back-up is formed in said separator and includes a plurality of protrusions spaced from each other.

6. A seal structure of a fuel cell according to claim 1, wherein said back-up is formed in said separator and includes a rib having a plurality of tunnels formed in said rib and spaced from each other.

7. A seal structure of a fuel cell according to claim 1, wherein an entire portion of said back-up located between adjacent separators is formed in either one separator of the adjacent separators.

8. A seal structure of a fuel cell according to claim 1, wherein a portion of said back-up located between adjacent separators is formed in one separator of the adjacent separators, and a remaining portion of said back-up located between adjacent separators is formed in the other separator of the adjacent separators.

9. A seal structure of a fuel cell, said fuel cell including an MEA, a separator, a gas passage formed in said separator, a gas manifold formed in said separator, a connecting gas passage formed in said separator and between said gas passage and said gas manifold, a coolant passage formed in said separator, a coolant manifold formed in said separator, a connecting coolant passage formed in said separator and between said coolant passage and said coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line, said seal structure of a fuel cell comprising an interrupted back-up disposed at at least one of said connecting gas passage and said connecting coolant passage, said back-up located on one side of said separator and a portion of seal line located on the other side of said separator being disposed such that said back-up and said portion of said seal line are overlapped with each other in a fuel cell stacking direction, characterized in that said interrupted back-up disposed at said connecting coolant passage is made from a seal material.

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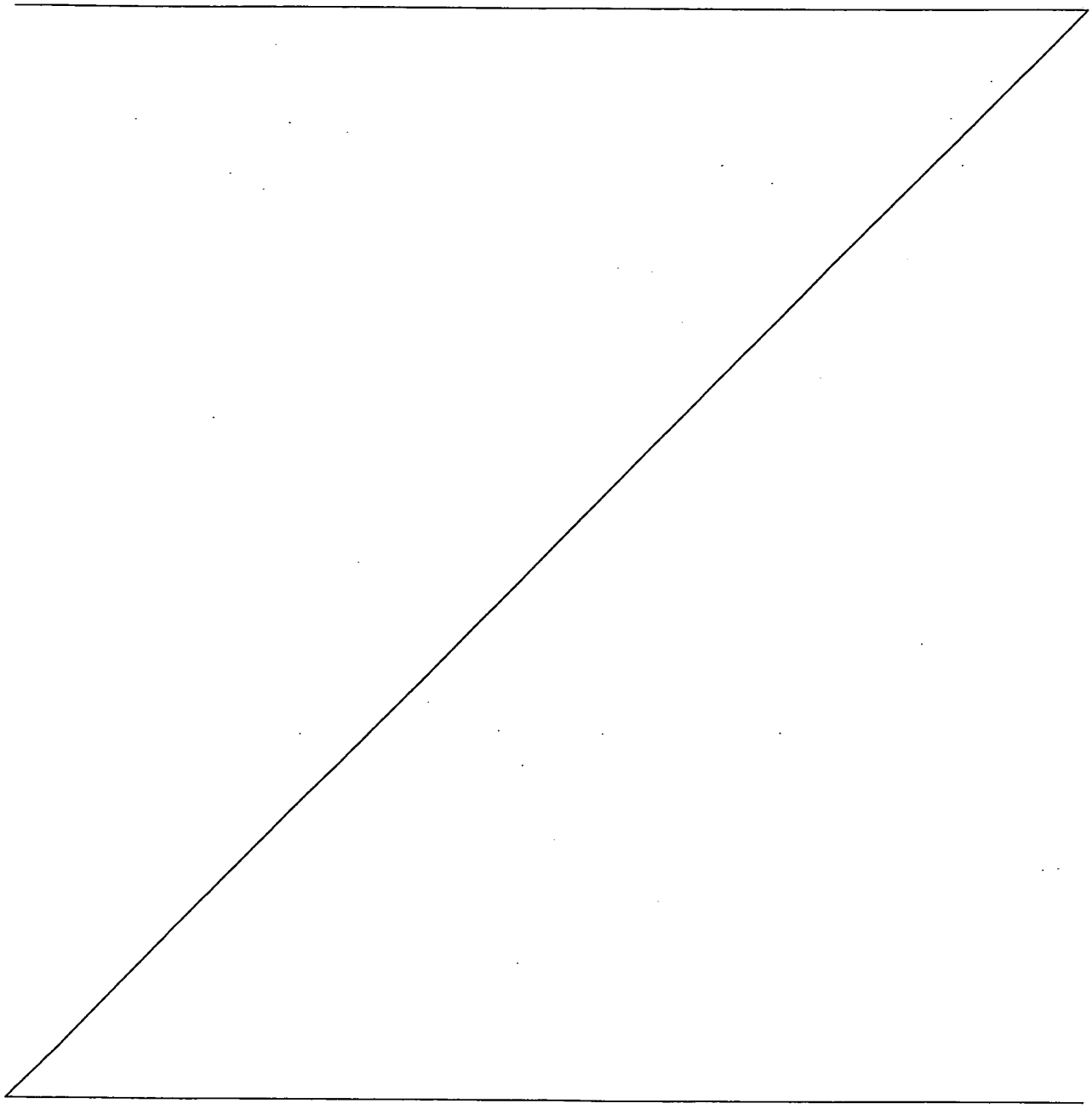
coolant manifold are different from each other, usually the gas seal line and the coolant seal line cannot be overlapped in the fuel cell stacking direction. As a result, the problem of the portion "B", that is, the problem that the seal line is bent and when the separator is deformed locally, the seal is separated from the separator to cause leakage, cannot be solved.



Document US 2003/0091885 A1 discloses an electrolyte membrane-gasket assembly for a fuel cell, including a polymer electrolyte membrane and a gasket, made of a seal material, covering the peripheral portion of the electrolyte membrane, in which the electrolyte membrane has a sequence of a plurality of through-holes in the peripheral portion, and a portion of the gasket covering one surface of the electrolyte membrane and a portion covering the other surface are connected to each other through the through-holes of the electrolyte membrane.

Document US 2003/0186106 A1 discloses a fuel cell stack comprising a plurality of fuel cells, each having an anode flow field plate, a cathode flow field plate and a membrane electrode assembly disposed between the flow field plates. The anode and cathode flow field plates have primary channels and ribs separating the primary channels. At least a portion of the anode and cathode primary channels are disposed directly opposite one another with a membrane exchange assembly therebetween and with at least some of the ribs on the anode and cathode flow field plates located directly opposite one another to sandwich the membrane exchange assembly therebetween.

Document US 2002/0182471 A1 discloses a sealing method and apparatus for a fuel cell stack that includes a stack of flow plates, a first gasket that is compatible with a coolant and a second gasket that is incompatible with the coolant. The first gasket forms a seal around a coolant manifold passageway between an adjacent pair of plates. At least one region of a particular plate may be associated with a reactant flow, and this plate may include internal passageways that extend between manifold passageways to communicate a coolant. A seal that is substantially permanent isolates the internal passageways from the regions of the fuel cell plate that may be associated with reactant flows.

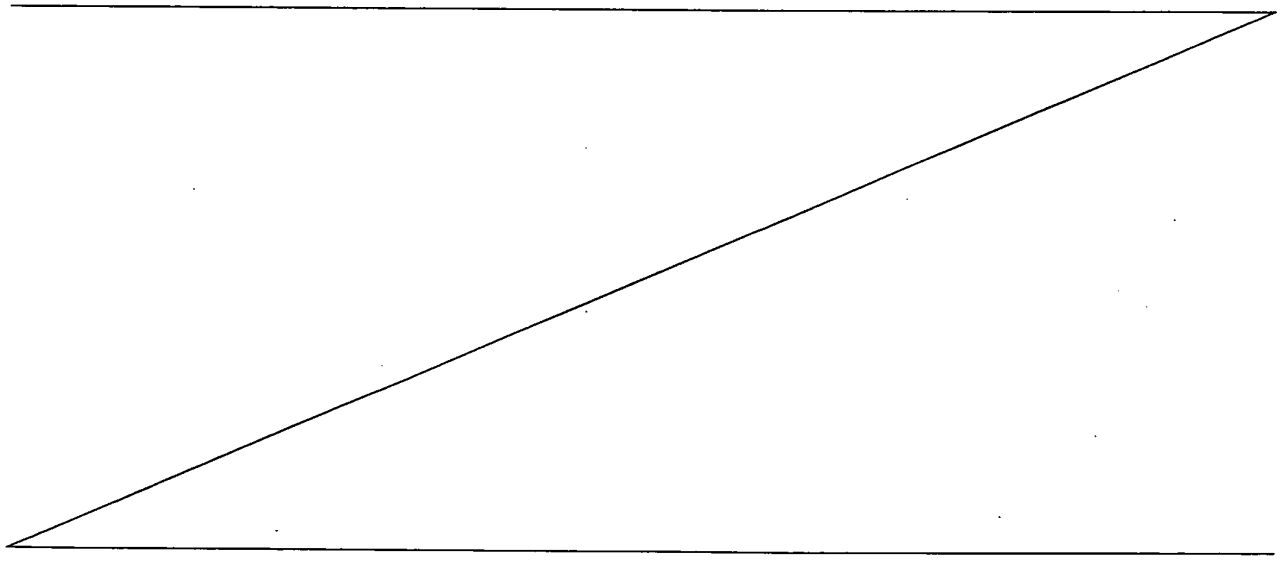
Document US 2003/0072988 A1 discloses seals for fuel cells and fuel cell stacks, wherein in a fuel cell stack assembly having a plurality of plates with grooves for

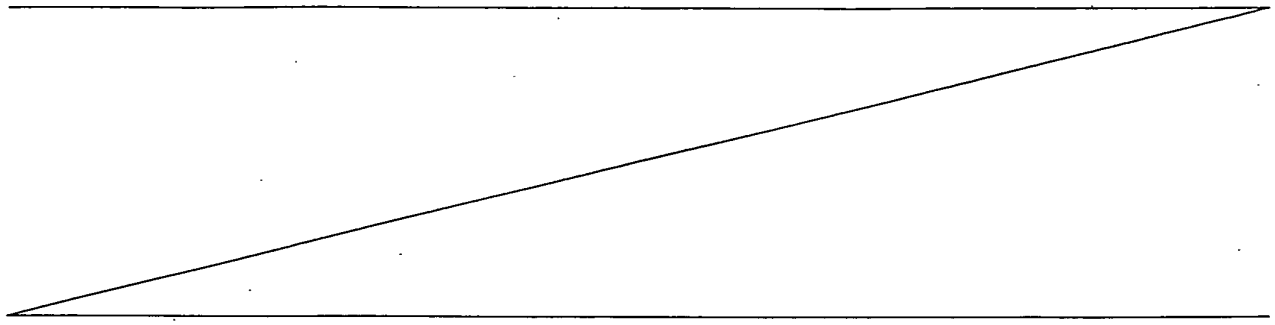
accommodating gaskets. Seals are provided between individual fuel cell plates in the fuel cell stack assembly in order to prevent leakage of gases and liquids required for operation of the fuel cell stack assembly.

Document US 2002/0031698 A1 discloses a fuel cell having sealant for sealing a solid polymer electrolyte membrane, wherein a seal contacts the projecting portion which extends from the solid polymer electrolyte membrane and which projects from the peripheries of the anode side diffusion electrode and the cathode side diffusion electrode while the membrane electrode assembly is disposed between the separators.

Document EP 1 302 996 A2 discloses a polymer electrolyte fuel cell comprising a unit cell comprising a membrane electrode assembly (MEA) comprising a polymer electrolyte membrane, a gasket covering the periphery of the electrolyte membrane, an anode and a cathode attached to the electrolyte membrane; and conductive separator plates sandwiching the MEA therebetween.

Document US 2002/0122970 A1 discloses a method for fabricating a seal-integrated separator for a fuel cell, wherein a seal-integrated separator having first to fourth seals which are integrated on both sides of the separator body is fabricated.





A first problem to be solved by the present invention is that at the gas and coolant connecting passages between the gas and coolant manifolds and the gas and coolant passages at the central portion of the fuel cell, one of the gas seal and the coolant seal at the opposite sides of the separator is not provided. As a result, the gas seal and the coolant seal at the opposite sides of the separator cannot operate as a back-up to each other, and sealing characteristic and stability of the seal on a backside of the interrupted seal portion are degraded.

A second problem to be solved by the present invention is that, in addition to the first problem, in the case where the width of the gas manifold and the width of the coolant manifold are different from each other, the gas seal line and the coolant seal line are not overlapped to each other, and sealing characteristic and stability of the non-overlapped portion of the seal line are degraded.

Summary of the Invention

A first object of the present invention is to provide a seal structure of a fuel cell where good sealing characteristic and good stability of a seal are assured even at gas and coolant connecting passages between the gas and coolant manifolds and the gas and coolant passages of a central portion of the fuel cell.

A second object of the present invention is, in addition to the first object, to provide a seal structure of a fuel cell where good sealing characteristic and good stability of a seal

are assured even when the a width of the gas manifold and a width of the coolant manifold are different from each other.

A seal structure of a fuel cell according to the present invention to achieve the above objects may be described as follows:

(1) A seal structure according to the present invention is for a fuel cell. The fuel cell includes an MEA, a separator, a gas passage formed in the separator, a gas manifold formed in the separator, a connecting gas passage formed in the separator and between the gas passage and the gas manifold, a coolant passage formed in the separator, a coolant manifold formed in the separator, a connecting coolant passage formed in the separator and between the coolant passage and the coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line.

The seal structure of a fuel cell according to the present invention includes an interrupted back-up disposed at at least one of the connecting gas passage and the connecting coolant passage. The back-up located on one side of the separator and a portion of seal line located on the other side of the separator are overlapped to each other in a fuel cell stacking direction, wherein said back-up may be formed in the separator and may include a rib having a convex and concave structure.

(2) The back-up may be disposed at the connecting gas passage between the gas passage of the central portion of the fuel cell and the gas manifold.

(3) The back-up may be disposed at the connecting coolant passage between the coolant passage of the central portion of the fuel cell and the coolant manifold.

(4) The gas manifold and the coolant manifold differs form each other in width. The interrupted back-up and a portion of the seal line positioned in an extension of the interrupted back-up are arranged to be disposed on or along a same straight line.

(5) In the seal structure of a fuel cell of item (1) above, the back-up is formed in the separator and may include a plurality of protrusions spaced from each other.

(6) In the seal structure of a fuel cell of item (1) above, the back-up is formed in the separator and may include a rib having a plurality of tunnels formed in the rib and spaced from each other.

(7) In the seal structure of a fuel cell of item (1) above, an entire portion of the back-up located between adjacent separators is formed in one of either separator of the adjacent separators.

(8) In the seal structure of a fuel cell of item (1) above, a portion of the back-up located between adjacent separators is formed in one separator of the adjacent separators, and a remaining portion of the back-up located between adjacent separators is formed in the other separator of the adjacent separators.

(9) A seal structure according to the present invention is for a fuel cell. The fuel cell includes an MEA, a separator, a gas passage formed in the separator, a gas manifold formed in the separator, a connecting gas passage formed in the separator and between the gas passage and the gas manifold, a coolant passage formed in the separator, a coolant manifold formed in the separator, a connecting coolant passage formed in the separator and between the coolant passage and the coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line.

The seal structure of a fuel cell according to the present invention includes an interrupted back-up disposed at at least one of the connecting gas passage and the connecting coolant passage. The back-up located on one side of the separator and a portion of seal line located on the other side of the separator are overlapped to each other in a fuel cell stacking direction, wherein said interrupted back-up disposed at said connecting coolant passage is made from a seal material.

With respect to a seal structure of a fuel cell according to the present invention, the following technical advantages are obtained:

According to the seal structure of a fuel cell described in items (1)-(9) above, since the interrupted back-up is formed at at least one of the connecting gas passage and the connecting coolant passage, and the interrupted back-up and the continuous seal line located on the backside of the interrupted back-up via the separator are overlapped in the fuel cell stacking direction, the continuous seal line and the separator are backed-up or supported by the interrupted back-up in the fuel cell stacking direction. As a result, even when a gas pressure acts on the separator, the separator will not be deformed and will not be separated from the continuous seal line, and the sealing characteristic and stability of the continuous seal will be maintained well.

Further, since the back-up is interrupted, flow of gas and coolant through the back-up between the manifold and the passage at the central portion of the fuel cell is maintained well.

According to the seal structure of a fuel cell described in item (1) above, since the interrupted back-up is formed in the separator, it is easy to form the interrupted back-up, because the seal structure can be obtained only by a design change of the connecting gas passage and the connecting coolant passage of the separator.

According to the seal structure of a fuel cell described in item (4) above, since the

interrupted back-up and the seal line located in the extension of the interrupted back-up are made straight irrespective of a difference between the width of the gas manifold and the width of the coolant manifold, the problem of a stress concentration at the corner of the seal line which is caused in a bent seal line is eliminated, and a good sealing characteristic and stability are obtained over the entire portion of the straight seal line.

Brief Description of the Drawings

The seal structure of a fuel cell according to the present invention will now be explained with reference to the accompanying drawings, in which:

FIG. 1 is a front elevational view of a front surface and a rear surface of a seal structure of a fuel cell according to a first embodiment of the present invention;

FIG. 2 is a cross-sectional view of the seal structure of FIG. 1 taken along line II-II;

FIG. 3 is a front elevational view of a front surface and a rear surface of a seal structure of a fuel cell according to a second embodiment of the present invention;

FIG. 4 is a cross-sectional view of the seal structure of FIG. 3 taken along line IV-IV;

FIG. 5 is a cross-sectional view of one example of a back-up of the seal structure of FIG. 3 taken along line V - V;

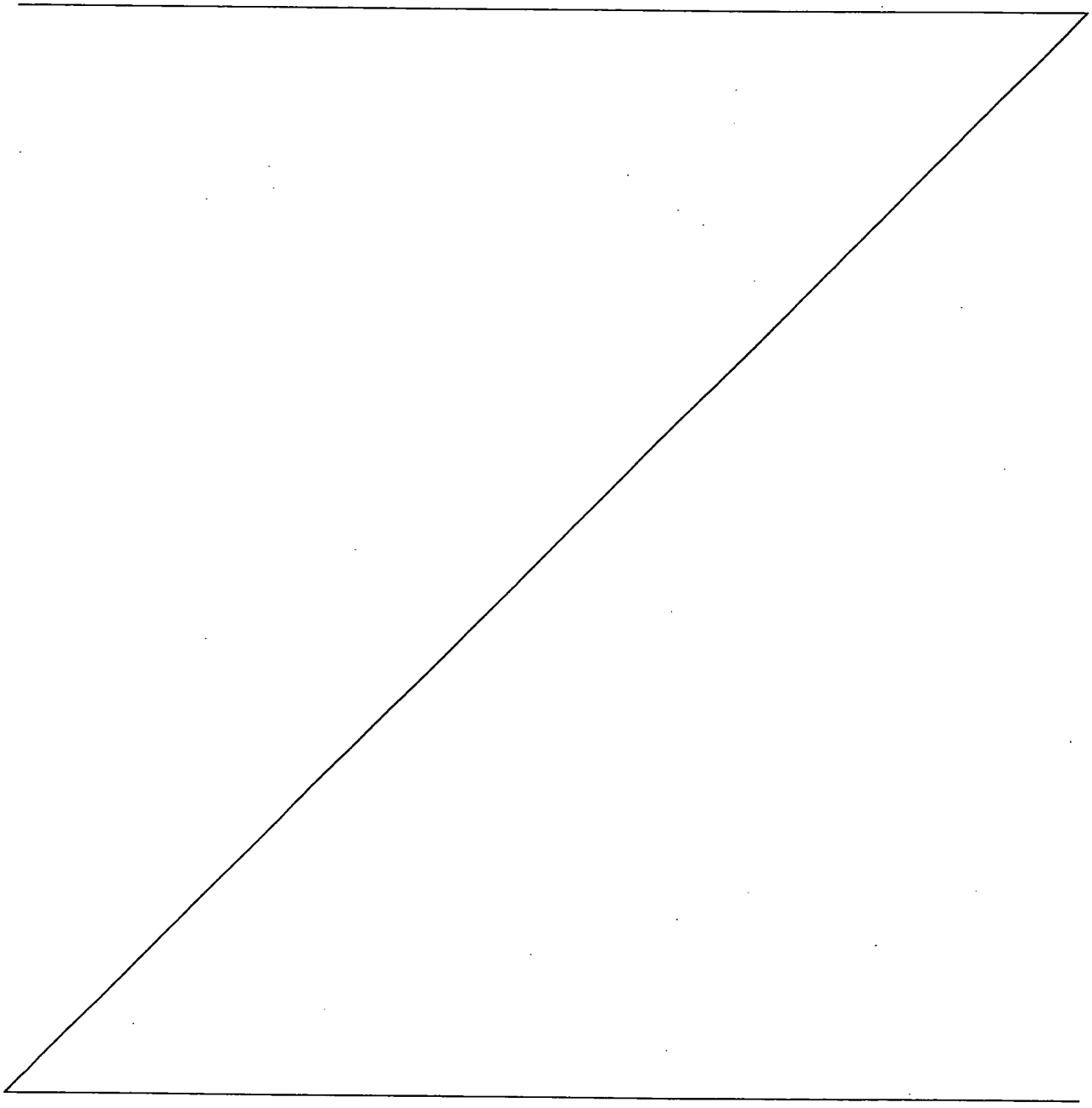
FIG. 6 is a cross-sectional view of another example of the back-up of the seal structure of FIG. 3 taken along line V - V;

FIG. 7 is a side elevational view of a fuel cell stack including the seal structure according to the present invention;

FIG. 8 is a front elevational view of a front surface and a rear surface of a seal structure of a conventional fuel cell; and

FIG. 9 is a cross-sectional view of the seal structure of FIG. 8 taken along line IX-

coolant manifold are different from each other, usually the gas seal line and the coolant seal line cannot be overlapped in the fuel cell stacking direction. As a result, the problem of the portion "B", that is, the problem that the seal line is bent and when the separator is deformed locally, the seal is separated from the separator to cause leakage, cannot be solved.



Document US 2003/0091885 A1 discloses an electrolyte membrane-gasket assembly for a fuel cell, including a polymer electrolyte membrane and a gasket, made of a seal material, covering the peripheral portion of the electrolyte membrane, in which the electrolyte membrane has a sequence of a plurality of through-holes in the peripheral portion, and a portion of the gasket covering one surface of the electrolyte membrane and a portion covering the other surface are connected to each other through the through-holes of the electrolyte membrane.

Document US 2003/0186106 A1 discloses a fuel cell stack comprising a plurality of fuel cells, each having an anode flow field plate, a cathode flow field plate and a membrane electrode assembly disposed between the flow field plates. The anode and cathode flow field plates have primary channels and ribs separating the primary channels. At least a portion of the anode and cathode primary channels are disposed directly opposite one another with a membrane exchange assembly therebetween and with at least some of the ribs on the anode and cathode flow field plates located directly opposite one another to sandwich the membrane exchange assembly therebetween.

Document US 2002/0182471 A1 discloses a sealing method and apparatus for a fuel cell stack that includes a stack of flow plates, a first gasket that is compatible with a coolant and a second gasket that is incompatible with the coolant. The first gasket forms a seal around a coolant manifold passageway between an adjacent pair of plates. At least one region of a particular plate may be associated with a reactant flow, and this plate may include internal passageways that extend between manifold passageways to communicate a coolant. A seal that is substantially permanent isolates the internal passageways from the regions of the fuel cell plate that may be associated with reactant flows.

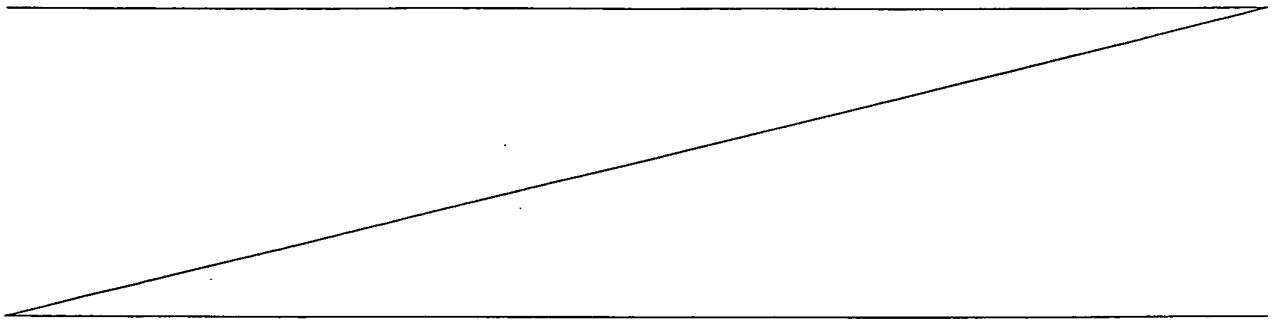
Document US 2003/0072988 A1 discloses seals for fuel cells and fuel cell stacks, wherein in a fuel cell stack assembly having a plurality of plates with grooves for

accommodating gaskets. Seals are provided between individual fuel cell plates in the fuel cell stack assembly in order to prevent leakage of gases and liquids required for operation of the fuel cell stack assembly.

Document US 2002/0031698 A1 discloses a fuel cell having sealant for sealing a solid polymer electrolyte membrane, wherein a seal contacts the projecting portion which extends from the solid polymer electrolyte membrane and which projects from the peripheries of the anode side diffusion electrode and the cathode side diffusion electrode while the membrane electrode assembly is disposed between the separators.

Document EP 1 302 996 A2 discloses a polymer electrolyte fuel cell comprising a unit cell comprising a membrane electrode assembly (MEA) comprising a polymer electrolyte membrane, a gasket covering the periphery of the electrolyte membrane, an anode and a cathode attached to the electrolyte membrane; and conductive separator plates sandwiching the MEA therebetween.

Document US 2002/0122970 A1 discloses a method for fabricating a seal-integrated separator for a fuel cell, wherein a seal-integrated separator having first to fourth seals which are integrated on both sides of the separator body is fabricated.



A first problem to be solved by the present invention is that at the gas and coolant connecting passages between the gas and coolant manifolds and the gas and coolant passages at the central portion of the fuel cell, one of the gas seal and the coolant seal at the opposite sides of the separator is not provided. As a result, the gas seal and the coolant seal at the opposite sides of the separator cannot operate as a back-up to each other, and sealing characteristic and stability of the seal on a backside of the interrupted seal portion are degraded.

A second problem to be solved by the present invention is that, in addition to the first problem, in the case where the width of the gas manifold and the width of the coolant manifold are different from each other, the gas seal line and the coolant seal line are not overlapped to each other, and sealing characteristic and stability of the non-overlapped portion of the seal line are degraded.

Summary of the Invention

A first object of the present invention is to provide a seal structure of a fuel cell where good sealing characteristic and good stability of a seal are assured even at gas and coolant connecting passages between the gas and coolant manifolds and the gas and coolant passages of a central portion of the fuel cell.

A second object of the present invention is, in addition to the first object, to provide a seal structure of a fuel cell where good sealing characteristic and good stability of a seal

are assured even when the a width of the gas manifold and a width of the coolant manifold are different from each other.

A seal structure of a fuel cell according to the present invention to achieve the above objects may be described as follows:

(1) A seal structure according to the present invention is for a fuel cell. The fuel cell includes an MEA, a separator, a gas passage formed in the separator, a gas manifold formed in the separator, a connecting gas passage formed in the separator and between the gas passage and the gas manifold, a coolant passage formed in the separator, a coolant manifold formed in the separator, a connecting coolant passage formed in the separator and between the coolant passage and the coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line.

The seal structure of a fuel cell according to the present invention includes an interrupted back-up disposed at at least one of the connecting gas passage and the connecting coolant passage. The back-up located on one side of the separator and a portion of seal line located on the other side of the separator are overlapped to each other in a fuel cell stacking direction, wherein said back-up may be formed in the separator and may include a rib having a convex and concave structure.

(2) The back-up may be disposed at the connecting gas passage between the gas passage of the central portion of the fuel cell and the gas manifold.

(3) The back-up may be disposed at the connecting coolant passage between the coolant passage of the central portion of the fuel cell and the coolant manifold.

~~(4) The back-up may be formed in the seal.~~

~~(5) The back-up may be formed in the separator.~~

(~~6~~4) The gas manifold and the coolant manifold differs form each other in width. The

interrupted back-up and a portion of the seal line positioned in an extension of the interrupted back-up are arranged to be disposed on or along a same straight line.

~~(7) In the seal structure of a fuel cell of item (1) above, the back-up is formed in the seal made from adhesive and coated in a form of a dotted line and the back-up includes each dot of the dotted line made from adhesive. The back-up includes a plurality of non-coated portions of adhesive which are spaced from each other in a back-up extending direction.~~

~~(8) In the seal structure of a fuel cell of item (1) above, the seal is made from a gasket (e.g., a rubber gasket) and the back-up is formed in the seal. The back-up includes a plurality of grooves or concaves (concavities) in a gasket material which are spaced from each other in a back-up extending direction.~~

~~(9) In the seal structure of a fuel cell of item (1) above, the back-up is formed in either one of the seal and the separator and may include a rib having a convex and concave structure.~~

(~~10~~5) In the seal structure of a fuel cell of item (1) above, the back-up is formed in ~~either one of the seal and~~ the separator and may include a plurality of protrusions spaced from each other.

(~~11~~6) In the seal structure of a fuel cell of item (1) above, the back-up is formed in ~~either one of the seal and~~ the separator and may include a rib having a plurality of tunnels formed in the rib and spaced from each other.

(~~12~~7) In the seal structure of a fuel cell of item (~~5~~1) above, an entire portion of the back-up located between adjacent separators is formed in one of either separator of the adjacent separators.

(~~13~~8) In the seal structure of a fuel cell of item (~~5~~1) above, a portion of the back-up located between adjacent separators is formed in one separator of the adjacent separators,

and a remaining portion of the back-up located between adjacent separators is formed in the other separator of the adjacent separators.

(9) A seal structure according to the present invention is for a fuel cell. The fuel cell includes an MEA, a separator, a gas passage formed in the separator, a gas manifold formed in the separator, a connecting gas passage formed in the separator and between the gas passage and the gas manifold, a coolant passage formed in the separator, a coolant manifold formed in the separator, a connecting coolant passage formed in the separator and between the coolant passage and the coolant manifold, and a seal for preventing gas and/or coolant from leaking and defining a continuous seal line.

The seal structure of a fuel cell according to the present invention includes an interrupted back-up disposed at at least one of the connecting gas passage and the connecting coolant passage. The back-up located on one side of the separator and a portion of seal line located on the other side of the separator are overlapped to each other in a fuel cell stacking direction, wherein said interrupted back-up disposed at said connecting coolant passage is made from a seal material.

With respect to a seal structure of a fuel cell according to the present invention, the following technical advantages are obtained:

According to the seal structure of a fuel cell described in items (1)-(~~13~~9) above, since the interrupted back-up is formed at at least one of the connecting gas passage and the connecting coolant passage, and the interrupted back-up and the continuous seal line located on the backside of the interrupted back-up via the separator are overlapped in the fuel cell stacking direction, the continuous seal line and the separator are backed-up or supported by the interrupted back-up in the fuel cell stacking direction. As a result, even when a gas pressure acts on the separator, the separator will not be deformed and will not

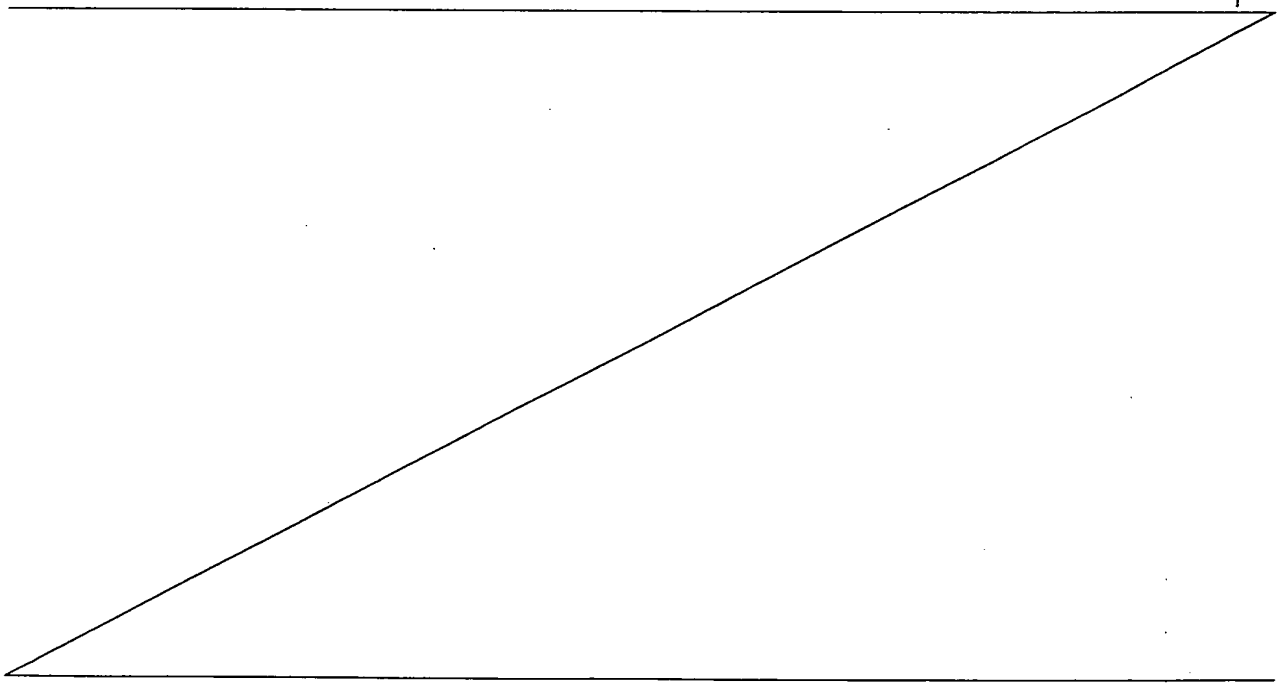
be separated from the continuous seal line, and the sealing characteristic and stability of the continuous seal will be maintained well.

Further, since the back-up is interrupted, flow of gas and coolant through the back-up between the manifold and the passage at the central portion of the fuel cell is maintained well.

~~According to the seal structure of a fuel cell described in item (4) above, since the interrupted back-up is formed in the seal, it is easy to form the interrupted back-up, because the back-up can be obtained only by a design change of the seal or a change in a coating method of the seal.~~

According to the seal structure of a fuel cell described in item (~~5~~1) above, since the interrupted back-up is formed in the separator, it is easy to form the interrupted back-up, because the seal structure can be obtained only by a design change of the connecting gas passage and the connecting coolant passage of the separator.

According to the seal structure of a fuel cell described in item (~~6~~4) above, since the



interrupted back-up and the seal line located in the extension of the interrupted back-up are made straight irrespective of a difference between the width of the gas manifold and the width of the coolant manifold, the problem of a stress concentration at the corner of the seal line which is caused in a bent seal line is eliminated, and a good sealing characteristic and stability are obtained over the entire portion of the straight seal line.

Brief Description of the Drawings

The seal structure of a fuel cell according to the present invention will now be explained with reference to the accompanying drawings, in which:

FIG. 1 is a front elevational view of a front surface and a rear surface of a seal structure of a fuel cell according to a first embodiment of the present invention;

FIG. 2 is a cross-sectional view of the seal structure of FIG. 1 taken along line II-II;

FIG. 3 is a front elevational view of a front surface and a rear surface of a seal structure of a fuel cell according to a second embodiment of the present invention;

FIG. 4 is a cross-sectional view of the seal structure of FIG. 3 taken along line IV-IV;

FIG. 5 is a cross-sectional view of one example of a back-up of the seal structure of FIG. 3 taken along line V - V;

FIG. 6 is a cross-sectional view of another example of the back-up of the seal structure of FIG. 3 taken along line V - V;

FIG. 7 is a side elevational view of a fuel cell stack including the seal structure according to the present invention;

FIG. 8 is a front elevational view of a front surface and a rear surface of a seal structure of a conventional fuel cell; and

FIG. 9 is a cross-sectional view of the seal structure of FIG. 8 taken along line IX-